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BILATERAL CERVICAL SYMPATHECTOMY FOR THE RELIEF OF EPILEPSY, WITH REPORT OF THREE CASES; NOTES ON THE PHYSIOLOGIC EFFECTS OF CUTTING THE SYMPATHETIC, AND ON THE HISTOLOGIC CHANGES FOUND IN THE CASES IN QUESTION.*

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Cervical sympathectomy as a therapeutic measure for the possible relief of epilepsy has been tried in enough cases to create a fairly extensive literature on the subject. In 1902, Winter collected all cases operated upon to that date, including nine of his own, and his extensive consideration of the subject comprising 203 cases, in which he gives the results in the form of a table, together with 5 cases reported by Hopkins[1] in March of the present year, makes it unnecessary to review all the literature up that time.

According to Winter, 6.6% of the 122 cases that were well observed were cured; 13.9% of them were "preliminarily"

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* Read before the New York Neurological Society, Dec. 6, 1904.

[1] S. D. Hopkins, "A Preliminary Report of Bilateral Excision of the Superior and Middle Cervical Sympathetic Ganglia in Five Cases of Epilepsy." New York Medical Journal and Philadelphia Medical Journal, March, 1904, p. 448.

WINTER'S TABLE.

		Number of Operations.	Cured.	Preliminarily Cured.	Improved.	Without Success i.e., No Result.	Dead.	Total Well Observed Cases.	Without Further News.
1.	Baracz	1	..	..	..	1	..	1	
2.	Alexander	24	4	2	3	13	1	23	1
3.	Jaksch	2	..	2	..	..	..	2	
4.	Kuemmel	1	..	..	1	..	..	1	
5.	Bogdanik	1	..	..	1	..	..	1	
6.	Pean	1	..	..	..	1	..	1	
7.	Jaboulay	16	..	1	4	10	1	16	
8.	Jonnesco	96	4	8	7	11	3	33	63
9.	Minin	1	..	..	..	1	..	1	
10.	Bayer	1	..	..	..	1	..	1	
11.	Chipault	26	..	3	..	..	..	3	23
12.	Donath	3	..	..	..	3	..	3	
13.	Schapiro	1	..	..	..	1	..	1	
14.	Richard	1	..	..	..	1	..	1	
15.	Potemsky-Sciamanna	7	..	..	1	6	..	7	
16.	Bourneville	1	..	..	..	1	..	1	
17.	Deschamps	2	..	..	..	..	..	..	2
18.	Souques	1	..	..	..	1	..	1	
19.	Dejerine	1	..	..	..	1	..	1	
20.	Braun	9	..	..	3	4	2	9	
21.	Mariani	8	..	..	2	6	..	8	
22.	Winter	9	..	1	1	5	..	7	2
		213	8	17	23	67	7	122	91

cured, 18.9% improved, 54.9% not improved, while 5.7% died.

We interpret the term "Preliminarily" cured as used by Winter to include cases in which the earlier effects of the operation were favorable, but in which the cases were not kept under observation long enough to permit a positive statement of a permanent cure.

Something might first be said on the rationale of this therapeutic procedure as based on anatomical and physiological facts:

The effect of the operation may be twofold: 1st, by cutting off a certain amount of sensory stimulation from the viscera, i.e., preventing these stimuli from reaching the brain; 2nd, by influencing directly the circulation of the brain by changes in the caliber of the blood vessels through the action of the vascular nerves.

The sensory functions of the sympathetic are much less known than are its motor functions, and for that reason it would be difficult to say in what manner the resection of the cervical sympathetic would affect the influx of visceral stimulation to the brain.

On the second point more definite data can be given. Huber[2] found two kinds of nerve fibers in the pia mater of the brain, medullated and non-medullated. He considers the former to be sensory. The non-medullated ones he considers to be vaso-motor nerves forming primary plexuses in the adventitia. Through frequent branches of the fibers of the latter, an interlacing network is formed. Within this plexus is formed a second plexus not so well defined, lying evidently internal to the muscular coat and giving off terminal fibrils in the muscular tissue of the vessels.

While there is thus established a histological basis to the theory of the presence of vascular nerves for the blood vessels supplying the brain, this theory is also apparently confirmed by physiological experiment.

Lafforgue[3] observed in rabbits as a direct result of stimulation of the cervical sympathetic nerve (peripheral stump) spasmodic ischemia of the whole cerebrum, cerebellum and oblongata.

Jonnesco,[4] making his studies on 15 epileptics on whom section or resection of the cervical sympathetic, unilaterally or bilaterally, was performed, concludes that the cervical sympathetic contains *vaso-constrictor* fibers for the *head,* face, and heart, made evident by excitation with strong electric currents; that it contains, furthermore, vaso-dilator fibers for the inner part of the cheeks and lips, for the gums, inner and lateral part of tongue, *and for the brain,* brought out by the application of feeble currents. Empirical facts have, of course, precedence over theoretical considerations, and if cervical sympathectomy would lead to a prepondering percentage of cures in epilepsy, or even improvements in epilepsy, we would have to accept the fact, no matter what its explanation might be. Nevertheless, we should always endeavor to explain facts. and this is particularly desirable in the case in view because of the circumstance that the percentage of cases benefited by the operation is by no means such as to warrant an unqualified justification of the operation in epilepsy.

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[2] "Observations on the Innervation of Intracranial Vessels." Jour. of Comp. Neurol., 1899, Vol. 9, No. 1.

[3] Lafforgue, E., "Rech. exper. sur l'action du grand symp. cerv. dans la production de certains accidents syncop. (syncopes reflexes)." Indep. médicale, 1897, p. 409.

[4] Jonnesco, "Physiologie du sympathique cervical," XIII. Congr. Internat. de Med. Section d'Histologie et d'Embryologie, 1900. Paris, 1901, comptes rendus, pp. 26-38.

Jonnesco and Floresco, "Physiologie du nerf sympathique cervical chez l'homme," Rapport par M .Franois Franck. Bull. de l'Acad. Medicine, 1900, 3eme s., Vol. XLIV., pp. 213, 214.

While the three cases we have to report will not add much to the casuistry of the operation in the way of percentage, the report may be of value from the fact that one of the patients presented an additional condition, a pronounced "tic" of the head and right arm, which in some manner we are unable to explain at this time, was radically improved by the operation in a way that seemed a year later would be lasting. A second factor in our cases was a thorough histological investigation of the parts of the sympathetic nerves that were extirpated. So far as we have been able to ascertain this has never before been done in cases of epilepsy.

POINTS IN EXCISION OF THE CERVICAL SYMPATHETIC BY DR. PARK.

In attacking the cervical sympathetic, it is worth while to remember that it contains dilator fibers for the pupil, motor fibers for the involuntary muscles of the orbit, vaso-constrictor fibers for the vessels of the head, secretory fibers for the salivary glands, and the accelatory fibers for the heart. There is perhaps no more mixed nerve in the body than this.

Its upper end may be recognized by its gangliform enlargement. The middle ganglion lies upon the inferior thyroid artery which is just below the carotid tubercle, i.e., the anterior tubercle of the 6th cervical vertebra.

The nerve may be best exposed by incision along the posterior border of the sterno-mastoid. It should be divided between its fibers, close to its inner side, in order to reach the inner fascia and to separate it from the deeper muscles after this fascia is divided. It must be separated close to the base of the skull where the upper ganglion will be found lying on the inner side of the anterior tubercle of the transverse processes of the second and third vertebræ and upon the muscles which are covered by the above fascia. Here, the lower end of the nerve having been identified, it should be caught with forceps and freed up to the base of the skull. Then the nerve trunk may be separated downward. The balance of the operation may be completed by continuing the above incision or by making another, beginning 1 cm. above the clavicle, along the posterior border of the sterno-mastoid and extending it upward 5 or 6 cm. The posterior border of this muscle must be exposed and separated upwards till the fingers meet in the tunnel thus made beneath it. The wound must be widely separated, the muscle drawn upward and forward, the inferior thyroid artery identified, and the middle ganglion found wherever it rests, which is usually inside the curve of the vessel. Sometimes this ganglion is replaced by a plexus, or the main branch of the nerve may pass behind the vessel. The nerve trunk should be caught at this point, and pulled upon so as to surely identify it with the cord still remaining in the upper wound. The identity having been made clear, the nerve trunk is loosened and drawn forward. The artery is freed from any plexus round it. Should one be operating upon a case of exophthalmic goiter it would be particularly desirable to separate and destroy the fibers of the middle cardiac nerve, which extends round and passes to the inner side of this thyroid artery. The nerve trunk, being drawn down beneath the artery, is followed outward and downwards to its lower ganglion where it lies behind the clavicle on the neck of the first rib, between the scalenus anticus and the longus colli. Care must be taken to avoid the vertebral vein which covers it.

The nerve trunks should be separated, if possible, from the efferent and afferent branches, and the vertebral artery should then be exposed, freed and drawn outward.

In goiter cases it is especially necessary to divide the cardiac branches, which form the lower cardiac nerve, as well as all the vertebral branches. After effecting all this separation the nerve trunk is drawn upward, loosened by gentle traction, and finally removed with the lower ganglion. This ganglion is exceedingly hard to expose in some necks. In cases of epilepsy it is perhaps not so necessary that this should be removed as in cases of goiter where it is the cardiac sympathetic which one is most anxious to influence.

LIFE HISTORIES OF CASES OPERATED UPON.

CASE I. A. S., male, aged 24 years; native of New York, single, and a clerk by occupation.

Family History.—Father and mother living, aged 46 and 41 respectively. Father had convulsions when younger, which were claimed to be "uremic." Mother has frequent headaches with "a feeling of weight in the head." A brother of 8 years has chorea. Maternal grandparents died at ages of 48 and 46 respectively, the cause of death in both being apoplexy.

Personal History.—Patient is first in line of birth of six children. He was born at full term after instrumental delivery. Mother reports that he received "slight cuts over cheek bones" at this time. He was breast-fed and began teething at the ninth month. Had "night terrors" during childhood and began to walk at the nineteenth month. He was subject to frequent attacks of epistaxia without apparent cause. When 8 months old he fell from a chair, striking on his face. The first epileptic convulsion appeared when he was 15 years old, the supposed cause being fright. A second attack occurred a week later. His aura consists of severe headaches and "spots before the eyes." A ball of fire, he states, appears "between his eyes," then "long lines of color" are seen and everything "appears to pass from left to right." Diplopia occurs and the seizure begins. He has marked convulsive movements of the face and right arm, which have been present since the age of 8 or 9 years. They are choreic in form and become more pronounced previous to a seizure, and they are especially marked when he becomes excited. He was admitted to the Colony in June, 1903. He had one seizure in that month, one in August, two in September and two in November.

He was operated on by Dr. Park on November 16, 1903, and had a seizure the day after the operation. After that they ceased entirely until the following April—a period of four months—when he had two, after which they again ceased and have not recurred to this time, a period of seven and one-half months.

Operation and Clinical Notes.—Examination made just before the operation on November 16. showed the following: Tall, well nourished man of 24; ruddy face, red ears.

Pupils equal, slightly wider than normal. Reaction to light sluggish, response to accommodation paradoxical, i.e., dilation instead of contraction.

Choreic Movements.—Sometimes under excitement, and again without apparent cause, patient exhibits twitching movements of the face and head. The twitchings are usually not symmetrical, usually more marked on right side. Sometimes there are only one or two, again a longer series in quick succession, clonic like, at other times they are chiefly tonic. ·In the face the twitchings often appear as grimaces, distortions of different kinds. They are at times accompanied by a coughing sound.

Arms also affected to some extent. Here the movements have a more choreic character (as they have to less extent also in the other parts affected.) *Deep reflexes of upper extremities, elicitable,* but weak, equal on both sides, *knee jerks* equal, of good strength, but not lively; *ankle jerks* both present, equal, no ankle clonus; *plantar reflex* very weak on both sides, of Babinski type on left; normal type on right. *Heart action* not increased in strength. Heart sounds all clear. No exaggeration of second aortic sound. Pulse slow, average beat, 53, but decidedly arythmic. From five to ten slow beats are followed by two or three rapid ones, so that if the slow ones alone were counted, the slowness of pulse would be still more apparent. The accelerations of the pulse are frequently concomitant with the twitching, although not always so. Pulse is rather full, though changing in tension. *Respiration* on the whole, slow, about 13, but it is influenced by the choreic twitchings, which affect also the respiratory muscles, making respiration at times faster and deeper and superseding sometimes the normal respiratory movements so as to cause two instead of one distinct muscular contraction in one phase. *Lungs*—Some wheezing, particularly on the right side, lower part; otherwise normal. *Legs* show motor restlessness, reminding of chorea, but the movements in them have less of a spasmodic character. *Hands* show no tremor. *Thyroid* not enlarged. *Liver* and *Spleen* not enlarged. *Abdomen* rather retracted and dense.

Both cervical sympathetic nerves were removed by Dr. Roswell Park, November 16, 1903. Both nerves were found accompanied by a chain of lymphatic glands, the surroundings of which show increase of connective tissue, causing numerous adhesions, so that it is difficult to reach the sympathetic nerves. The latter, themselves, are strongly involved in the adhesions.

After section of the first cervical sympathetic (left), the pulse became very bounding; after the removal of the second it became still more so, but the difference was not so marked as after the removal of the left alone.

Both sympathetics preserved in 6 per cent. formaline immediately after removal. Apparently most of both upper cervical sympathetic ganglia and both middle cervical ganglia were removed and parts of the nerve below the latter.

Pupils became contracted while patient was still deeply anesthetic under ether.

The pulse became much less full by the time the patient was removed from operating table.

November 17.—Patient vomited once after operation. Did not sleep during night. *Face* of same color as before operation, perhaps slightly more congested. Conjuctiva slightly injected. *Pupils* both markedly contracted, but equal. Well marked ptosis on both sides. Pulse 68, rather bounding, but considerably less than directly after removal of sympathetic. Apparently less choreic twitchings before operation.

November 18.—Pulse about 120, but so erratic that it is hard to count it, and especially since every movement of patient gives a marked acceleration. Had an epileptic attack this morning, 9:40 Half hour later, restless and confused. Speech thick and blurred; one can hardly understand what he says.

November 20.—Complains of numbness of left ear and region behind ear, also of numbness under the chin. Same symptoms existed to less extent on right side, but have now disappeared. The numbness appeared after the operation.

The posterior surface of left ear and an area behind the latter, about one inch wide, show impairment of tactile sense.

Knee-jerks with Jendrassik rather subnormal, sluggish.

The patient made a rapid and satisfactory recovery from the operation.

Histological Notes (Case A.S.)—The two cervical sympathetic nerves in this case were put in 6 per cent. formaline immediately after removal, and their histological examination gave the following results:

Left Nerve.—Transverse sections stained after Busch showed no change. No inflammatory or vascular changes.

Right Nerve (below superior cervical ganglion).—Weigert and Pal sections, some cut transversely, some obliquely, show the medullated fibers normal for the most part.

Some small areas are unstained, but as these differ in different sections they are probably artefacts. Only few fibers show irregularities of caliber. Busch sections (longitudinal) are negative.

Below the upper cervical ganglion the nerve seems to consist almost entirely of medullated fibers.

Right Superior Cervical Ganglion.—Busch sepecimens (unstained or counterstained) show pigmentation of nerve cells chiefly in the peripheral zones of the cells otherwise negative. No inflammatory or vascular changes. Cells show no atrophic changes whatever.

Right middle cervical ganglion shows an inflammatory focus with tortuosity and dilatation of vessels.

Nissl specimens of this ganglion show too much artificial shrinkage (due probably to over-heating during the process of paraffine embedding) to allow very definite conclusions. The cells, however, seem normal so far as structure of the stained substance (Nissl bodies) is concerned.

The medullated nerve fibers of this ganglion show rather even caliber and are apparently normal.

Plate I

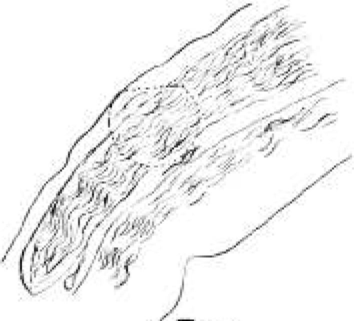

Fig I

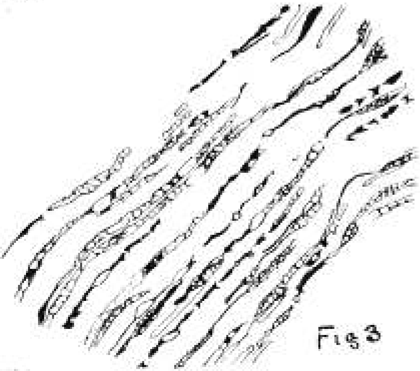

Fig 3

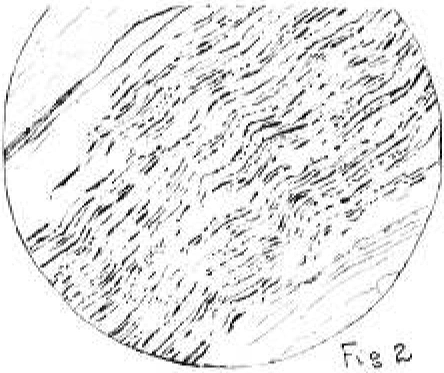

Fig 2

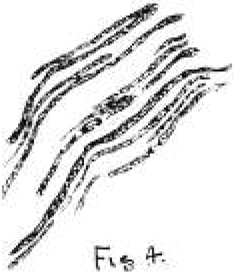

Fig 4.

Plate 2.

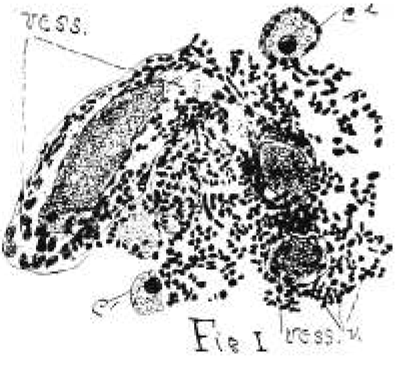

Fig I

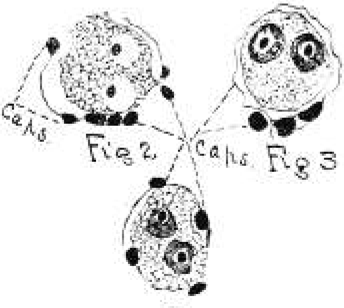

Fig 2

Fig 3

Fig 4

Left upper cervical ganglion: Nissl specimens show only a few cells pigmented. Relatively slight shrinkage, evidently artificial, since celloidine sections show no such shrinkage.

Chromophile structure apparently normal. In the specimens from which the sections stained with Bohmer hematoxylin and eosine and the sections stained after Van Gieson were taken, pigmented cells are more numerous, but also not a great number.

Nerve fibers in Wolters-Weigert specimens show marked irregularities in caliber, and seem rather scarce (?).

Left middle cervical ganglion: Nissl specimens present nothing abnormal except on one section a cell with a double nucleus and the presence of numerous pigmented cells. The cell with the double nucleus is illustrated in Plate II., Figure 2;—caps. is the surrounding capsule of the cell with nuclei embedded in it.

Busch specimens also show pigmentation of a number of cells.

Case II. (H. B.)—Age twenty-two years; no occupation, single.

Family History.—Both parents living. Mother subject to headaches; father a moderate drinker; a maternal aunt is insane; maternal grandfather, rheumatic. Maternal grandmother died of "tumor," paternal grandfather of cancer, and paternal grandmother of heart disease.

Personal History.—Patient is fourth in line of birth of five children. Normal birth at full term; said to have been a strong child; teething commenced at the 8th month. No history of spasms or convulsions at the time; commenced to walk about the 15th month.

First epileptic seizure occurred at the 18th month when she had a series of them; the cause being unknown. Aura consists of vertigo with marked flushing of face. Has a left hemiplegia, indistinct in character, and probably due to a cerebral hemorrhage that was caused by the first series of convulsions.

She was admitted to the Craig Colony in May, 1902. She had an attack that month; one in July and five in October following. During the next year she had four attacks only. She was operated on by Dr. Park on November 16, 1903.

The left sympathetic nerve was removed comparatively easily. No such chain of lymphatic glands and adhesions being present here as in the cases of A. S. and G. S. operated upon to-day.

After removal of the nerve, pulse became fuller and went down from 108 to 84.

On the right side a piece of nerve was removed, but the fact that it has no distinct ganglioniform enlargement makes it very doubtful whether it is the sympathetic. This doubt becomes confirmed by the fact that histologically no nerve cells could be made out in the resected piece, and is also clinically confirmed by the absence of contraction of the pupil of that side after the operation, furthermore, after the removal of this second nerve the pulse did not become fuller than it was after removal of the left sympathetic.

November 17.—Patient shows ptosis of the left upper lid, contraction of left pupil and some injection of vessels of lower half of left conjunctiva.

Right pupil not contracted. No ptosis on right side. Face is not more congested than before operation. It is evenly and strongly reddened on both sides.

Histological Notes (Case H. B.)—The removed left sympathetic was put in 10 per cent. formalin immediately after removal.

It proved to consist only of the left superior cervical ganglion plus the cord below, without the middle cervical ganglion.

The piece resected on the right side was not the sympathetic, but some other nerve.

Left superior cervical ganglion: The Nissl specimens are considerably shrunken owing to over-heating during paraffine embedding. While this makes interpretation difficult, the chromophile structure of the cells was apparently normal.

A fair number of cells show pigmentation. Three cells show a double nucleus, one apparently a triple nucleus, although the latter structure is somewhat doubtful of interpretation. No inflammatory changes found, no vascular ectasies.

Left nerve below superior cervical ganglion: Weigert specimens were lost.

Busch specimens showed no changes.

Case III. (G. S.)—Female, age twenty-six years, native of New York, housewife.

Family History.—Father living, aged seventy years. Mother died at age of forty-four years of typhoid fever. Paternal grandparents died at ages of seventy-three and eighty years respectively. Maternal grandfather died of tuberculosis. Maternal grandmother at age of ninety years. A paternal aunt had epilepsy. Mother had "fainting spells" and rheumatism. Father, rheumatic.

Personal History.—Patient was fourth in line of birth of five children. Born at full term after a normal labor. Delivery normal. She was a strong child, and began teething about the 8th month. No spasms or convulsions during first dentition. She had measles at the age of five, and diphtheria at six years. At age of seven years she fell and "bumped" her head on a table. When four years old, she had an attack of cholera infantum attended by convulsions, which disappeared on recovery from the cholera infantum. The first genuine epileptic attack is said to have occurred at the seventh year, during convalescence from typhoid fever. She was mentally disturbed during fever. Her attacks are preceded by vertigo and general numbness of body. Before admission to the Colony her attacks occurred from 3 to 10 days apart. During series of attacks her face becomes very red, she is feverish, and complains of prostration. She was married in her eighteenth year and has three children. No miscarriages. Lacerated cervix uteri. She has an aura about half an hour before her seizures in the nature of "gastric distress," and says this has been the case since the birth of her first child—ten years ago. Before that she experienced a "faint feeling" in the stomach ten minutes before the onset of the attack. She also complains that "her face burns like fire before attacks."

She was operated on by Dr. Park on November 16, 1903, and the day following the operation she had a double ptosis more marked on the left side. This condition completely disappeared in about two weeks.

Both nerves were found involved in numerous adhesions accompanied by a chain of lymphatic glands as in the case of A. S.

Left nerve was not preserved. Right one was found to be unusually thin. The resected piece contained the right upper cervical sympathetic ganglion and a piece of the nerve below.

November 17.—Patient has not vomited; slept about two hours and a half in the night.

Face is markedly congested, but patient says it was always red.

Ptosis of both upper lids, slightly more marked on right side. Pupils both equal and contracted, responding only slightly to light. Pulse 120, rather small; respiration 22. Pulse full and bounding.

Histological Notes (Case G. S.)—In this case only a piece of the right superior cervical ganglion and a piece of the nerve below were examined; the left cervical sympathetic was not preserved.

Right superior cervical ganglion: A considerable number of nerve cells of this ganglion show pigmentation in slight degree, and one nerve cell at least in the ganglion showed two nuclei very clearly, each with a nucleolus. The section showing it was stained after Van Gieson. (See Plate II., Figure 3, illustrating the cell with its two nuclei and with the surrounding capsule *(caps.)*.

Nerve.—The right cervical sympathetic nerve below the superior cervical ganglion showed some changes in its medullated fibers which at first glance seemed pathological in a marked degree. The medullary sheaths showed great irregularity of stain in sections stained after Wolters-Weigert or Wolters-Pal. An illustration of them is given in Plate I., Figures 2 and 3, both showing the same region of the nerve under different magnifying power. Plate I., Figure 1, shows diagrammatically the nerve in its entire thickness. The dotted line in this figure represents the entire area illustrated in Figure 2.

As it was suspected that the irregular staining might be the result of formalin hardening, the sympathetic nerve of an apparently normal sheep, also hardened in formalin, was used for comparison, and inspection of Plate II., Figure 4, will show that here too, the medullary sheaths show the same mottled appearance, which must, therefore, be attributed to the hardening. At the same time, it is noted that the nerve fibers of the normal sheep do not show the marked irregularities of caliber seen in the nerve of the patient and illustrated in Figures 2 and 3.

EPICRISIS OF THE HISTOLOGICAL CHANGES FOUND.

The changes found in the removed sympathetic nerves of the three operated cases are in essence as follows:

1. Pigmentation of a greater or less number of nerve cells of the cervical ganglia in all three cases.
2. Presence in every one of the three cases of at least one nerve cell with double nucleus in some one of the extirpated ganglia. In one of the cases about half a dozen such cells were found.
3. Degenerative changes in the medullated nerve fibers in the sympathetic cord and ganglia of the excised portion.
4. In one case (A. S.) a focus of inflammation, i.e., of perivascular round cell infiltration.

We will touch briefly upon the significance of the pigmented cells. It has been found in so many pathological studies that its true interpretation is difficult. Whether the constancy with which changes found in the nerve cells of senile people allows us to consider it as a sign of senility of the nerve cell, remains questionable in view of the fact that certain nerve cells (i.e., of the substantia nigra Soemmeringi and substantia ferrugine) are pigmented normally. Whether they also possess normal function, it is rather difficult to say before more is known on this point. The view that they might possibly represent a phylogenetic senility is purely speculative.

But a point of interest, warranting discussion, is the presence of nerve cells with two nuclei found in all three operated cases. It should be pointed out that in making this observation great care was taken not to mistake the nuclei of the capsule of the cells for intracellular nuclei or nucleoli, and, furthermore, not to mistake two closely adjoining cells for one cell with two nuclei. The "Nissl" stained cell with double nucleus gave a particularly clear, unmistakable picture.

But we must remember that in the sympathetic nervous system of certain mammalians, certain cells with two nuclei are not unusual. Schwalbe[5] has shown mononuclear as well as binuclear cells in the ganglia of the sympathetic chain of young rabbits. With advancing age the number of monuclear cells decreases in the same proportion to which the binuclear ones increase, so that the mononuclear cells are to be considered as a fore-stage of the binuclear. According to Apolant[6] and Schwalbe, the binuclear cells are found also in the large abdominal ganglia and in the smaller cardiac ganglia. Huber[7] found them in the solar ganglion.

Their frequent occurrence in the sympathetic nervous system even gave rise to an attempt to utilize this feature for assigning ganglia or sporadic cells to the sympathetic or cerebrospinal system respectively. Since, however, Key and Retzius[8] found occasional cells with a double nucleus also in spinal ganglia of rabbits, the binuclearity of the nerve cells cannot be considered as absolutely diagnostic of the sympathetic system.

In the sympathetic nervous system of man, cells with a double nucleus are evidently rare. This was pointed out by Brueckner[9] in a paper on "The Fine Structure of the Sympathetic Cells," published in 1898.

In the central nervous system of man, Brueckner found cells with two nuclei in healthy individuals as well as in a patient with typhoid fever, and in a piece of brain which Jonnesco extirpated in a case of Jacksonian epilepsy followed by recovery.

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[5] Schwalbe, "Uber den Bau der Spinalganglien," etc., Arch. f. mikr. Anat. Bd. IV., 1868.

[6] H. Apolant, "Ueber die sympathischen Ganglienzellen der Nager," Arch. f. mikr. Anat. Bd. 47, p. 461, 1896.

[7] G. Carl Huber, "A Contribution on the Minute Anatomy of the Sympathetic Ganglia of the Different Classes of Vertebrates," Journal of Morphology, Vol. XVI., No. 1, 1889.

[8] Key and Retzius, quoted by Apolant, l. c.

[9] Brueckner, Arch. des Sciences Médicales, Vol. III., 1898, p. 197.

In view of these facts, it is questionable whether the presence of binuclear cells in the removed cervical sympathetic of our three operated cases has any bearing, direct or indirect, on the epilepsy. For the present it is simply to be signalled as a fact that the binuclear cells were found in the cervical sympathetic in three successive cases in which these nerves were removed. Future observation will have to show whether such cells are not found with equal frequency in healthy individuals or in other pathological states.

The following observation still deserves notice in this connection: Obregia and Bresnia[10] after electrical excitation of leeches found that part of the nerve cells of this animal increased in size and presented all at once two nuclei which moved away from each other towards the two "extremities" (poles) of the cell. The latter begins to show a slight furrow, which becomes more and more accentuated until it finally leads to complete division of the cell. As they never observed a karyo-kinesis, they concluded that this multiplication occurs by simple division,* and explain in this manner also the regeneration of brain observed after experimental extirpation by Vitzu and Tedeschi.

These interesting facts certainly call for further experimentation and it would be premature now to offer any definite conclusions in regard to them.

As to the inflammatory focus found in the second case (Stern) operated on by Dr. Park, it is doubtful how much importance should be attributed to it. It was undeniably the most marked of all the changes found, and it corresponds to a degree, with the gross changes observed by Dr. Park in connection with the sympathetic, i.e., the adhesions of the nerve and swelling of the lymphatic glands accompanying it. But the question occurs as to whether these inflammatory changes were primary and whether the irritation of the sympathetic produced by them had any causal relation to the epileptic seizures, or whether on the contrary, the circulatory disturbances and changes of metabolism produced by the seizures themselves led secondarily to the inflammatory changes in and around the cervical sympathetic nerves.

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* It is appropriate to mention here that in the cervical sympathetic of the cases operated on by Dr. Park, no cells presenting signs of karyokinesis were found.

[10] Obregia and Bresnia: From Brueckner, l. c.

To decide this question the material was not sufficient. It is important that the sympathetic nerve be examined in cases in which it is removed for therapeutic purposes in epilepsy, and which, peculiarly enough, seems never to have been done to this time: at least so extensive a contribution to cervical sympathectomy in epilepsy as the paper of Winter,[11] that containing a discussion of 203 cases is entirely silent on this point; and Jonnesco,[12] who has done so much work along the same line, simply points out the "frequency with which lesions of the cervical sympathetic were found in association with ophthalmic goiter and epilepsy," without offering any substantiation to his statement. Indeed, our search of the literature for anatomical reports of lesions of this nerve in epilepsy has so far been entirely negative. Yet if cervical sympathectomy is so frequently resorted to as a therapeutic procedure in epilepsy, with a view of correcting circulatory conditions in the brain and the influx of visceral stimuli to the latter, it is but natural to eventually look for the cause of these anomalous conditions in the sympathetic nerve itself. In the light of the foregoing it would seem appropriate to histologically investigate the cervical sympathetic in such cases.

A few words in conclusion about the degenerative changes found in the medullated nerve fibers of the removed cervical sympathetics of the cases of G. S. and A. S. They were not very well marked and left some doubt as to their true interpretation. One conclusion to be reached is that preliminary formaline hardening is not favorable to the preservation of the medullated nerve fibers in the sympathetic, and should be supplemented by osmic acid teased specimens. The Busch modifications of the Marchi method was unsatisfactory. New methods, bringing out the fibrillary structure of the axis cylinder will eventually have to be resorted to, for investigating the condition of the non-medullated fibers of the sympathetic. They seem the only ones promising to throw light on the conditions of these fibers in pathological conditions, although the lack of reliability of most of them makes it doubtful whether they can be successfully applied for the purpose.

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[11] Winter, Archiv. fuer Klinische Chirurgie, 1902, p. 816.

[12] Jonnesco, Centralbl. fuer Chirurgie, Jan. 16, 1897, p. 33.

We express our appreciation of the very valuable services rendered us in the preparation of this paper by Dr. B. Onuf, the resident pathologist at the Craig Colony for Epileptics.

EXPLANATION OF PLATE I.

Figures 1, 2 and 3 represent a piece of the right cervical sympathetic nerve of case G. S.

Figure 1 illustrates the nerve diagrammatically in its entire thickness (magnified sixty-five times in diameter).

Figue 2 (magnified 300 times in diameter) represents the area enclosed in the dotted line of Figure 1.

Figure 3 shows a portion of the sympathetic nerve of an apparently normal sheep (under oil immersion, magnified 750 times in diameter).

EXPLANATION OF PLATE II.

Figure 1. Inflammatory focus in the right middle cervical sympathetic ganglion of case "Stern." vess.. bloodvessel; r., round cells; c', nerve cell; c', nerve cell with capsule.

Figure 2. Nerve cell with two nuclei, each nucleus with a nucleolus; taken from the left middle cervical sympathetic ganglion of case "Stern." Nissle stain (oil immersion, magnified 750 times in diameter); caps., capsule surrounding the cell.

Figure 3. Binuclear nerve cell from the right superior cervical ganglion of case "Grace Sheffield." Van Gieson stain (oil immersion, magnified 750 times in diameter); caps., capsule.

Figure 4. Binuclear cell from left superior cervical ganglion of case "Harriet Baker." Van Gieson stain (oil immersion, magnified 750 times in diameter); caps., capsule.